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A Note On the Empirical Interrelationships Among the Mundell and Darby Hypotheses and Expected Stock Market Returns

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ABSTRACT

This paper examines the Mundell wealth-effect hypothesis and the Darby tax-effect hypothesis in the context of a "generalized" Fisher equation for stock market returns. The empirical findings show that 1) a negative relationship exists between the expected real stock market return and the _level_ of expected inflation, which is consistent with the Mundell wealth-effect hypothesis; 2) the real required return for common stocks appears to have increased in response to increased inflation uncertainty, which may account for relatively depressed real stock prices during recent inflationary periods; and 3) the findings are _not_ supportive of the Darby tax-effect hypothesis.

INTRODUCTION

The objective of this note is to develop and test a proper empirical framework for explaining the *ex ante* relationship between *expected* (required) returns for common stocks and *expected* inflation. Using the Livingston expectations data base, our empirical model employs a "generalized" Fisher equation[1] for stock returns, adjusted for risk aversion and real and inflation uncertainty.

In brief, the empirical findings suggest that expected inflation is *negatively* related to the real required return for common stocks, which is consistent with the Mundell [1963] wealth-effect hypothesis;[2] but the real required return for common stocks increases as a response to increased inflation uncertainty, which may account for relatively depressed real stock prices during recent inflationary periods. The results suggest that the Darby [1975] tax-effect[3] does not appear to be important empirically.

The presentation is divided into three sections. Section I presents the generalized Fisher equation for stock market returns within a standard CAPM framework. Section II discusses the data base, estimation procedure, and empirical findings. Section III suggests additional avenues for future research.

I. THE "GENERALIZED" FISHER EQUATION FOR STOCK MARKET RETURNS

In an economy where risk averse individuals hold market portfolios of common stocks and nominally risk-free bonds, maximization of expected utility of real wealth by investors leads to the market equilibrium condition:[4]

$$E[r_s - r_o] = \lambda\{COV(r_o, r_s - r_o) + \alpha_s VAR(r_s - r_o)\} \tag{1}$$

where r_s and r_o are <u>after tax real</u> returns on common stocks and bonds, respectively; λ is the market price of risk; and α_s is the fraction of total wealth invested in common stocks.

In order to distinguish inflation uncertainty from real uncertainty, we assume that the unexpected real stock market return after tax is generated by a linear factor model, equation (2):

$$r_s - E[r_s] = b_s \pi^u + \varepsilon_s; \; COV(\pi^u, \varepsilon_s) = 0 \tag{2}$$

where π^u is the unexpected inflation rate with mean zero and variance σ_π^2; $b_s = COV(r_s, \pi^u)/\sigma_\pi^2$; and ε_s has mean zero and variance σ_ε^2. Real uncertainty and inflation uncertainty are represented by σ_ε^2 and σ_π^2, respectively.

For a nominally fixed interest rate, the unexpected ex post real interest rate, $r_o - E[r_o]$, is defined by equation (3):

$$r_o - E[r_o] \equiv -\pi^u \tag{3}$$

From equations (2) and (3), $COV(r_o, r_s - r_o) = -(1+b_s)\sigma_\pi^2$; and $VAR(r_s - r_o) = \sigma_\varepsilon^2 + (1+b_s)^2\sigma_\pi^2$. Hence, equation (1) can be rewritten as:

$$E[r_s - r_o] = \lambda\alpha_s\sigma_\varepsilon^2 + \lambda\{(1+b_s)^2\alpha_s - (1+b_s)\}\sigma_\pi^2 \tag{4}$$

If the Darby tax-effect exists, the ex ante pre-tax <u>nominal</u> rate of return for common stocks, $E[R_s]$, would be expressed as:

$$E[R_s] = E[r_s]/(1-\tau) + \delta_s E[\pi] \tag{5}$$

where τ is the effective weighted average personal income tax rate; and δ_s measures the magnitude of the Darby tax-effect in the stock market, i.e., $\delta_s = 1/(1-\tau) > 1.0$.

Using equation (5), equation (4) is rearranged to be the generalized Fisher equation for stock market returns, equation (6):

$$E[R_s] = \frac{1}{1-\tau} E[r_o] + \delta_s E[\pi] + \frac{\lambda\alpha_s}{1-\tau} \sigma_\varepsilon^2 + \frac{\lambda}{1-\tau} \left\{(1+b_s)^2\alpha_s - (1+b_s)\right\}\sigma_\pi^2 \qquad (6)$$

As is well-known, equation (6) illustrates that the Fisher equation may not hold in the joint presence of risk aversion and uncertainty. If there were no uncertainty ($\sigma_\varepsilon^2 = \sigma_\pi^2 = 0$), or if investors were risk neutral ($\lambda=0$), equation (6) would reduce to the standard Fisher equation, abstracting from the Darby tax-effect.

Available empirical evidence indicates that b_s in equations (4) and (6) is less than -1.0.[5] This finding implies, assuming α_s is about 2/3, that the required return for common stocks increases when inflation uncertainty increases. Intuitive appeal as well as empirical evidence[6] suggest that the level of actual and/or expected inflation and the degree of inflation uncertainty are not statistically independent. To the extent this relationship exists, we must estimate the magnitude of the effect of expected inflation on the required return for common stocks while simultaneously controlling for inflation uncertainty; otherwise our estimated coefficients may suffer from misspecification bias.[7]

II. THE EMPIRICAL ANALYSIS

II.1. The Data Base

For each of the semi-annual Livingston surveys from June 1955 through June 1980, the expected stock market return and the expected inflation rate are estimated from the arithmetic averages of individual respondents' six-month forecasts for the nominal stock market return ($E^{\ell}R_s$) and inflation rate ($E^{\ell}\pi$).[8] The logarithm of the cross-sectional variance of individual respondents' forecasted inflation rates (v_{π})[9] and the observed forecast errors of previous inflation predictions ($\hat{\pi}^u$, i.e., Livingston unexpected inflation rates)[10] are used as alternative surrogate measures of inflation uncertainty, σ_{π}^2. Real uncertainty, σ_{ε}^2, is proxied by the logarithm of the cross-sectional variance of individual respondents' forecasted real growth rates of the industrial production index (v_{ε}). Finally, the pre-tax nominal interest rate is measured by the six-month Treasury bill rate at the beginning of the month in which the corresponding Livingston survey was conducted (R_o).

II.2. Empirical Findings

Given our data base for the expected stock market return, expected inflation, inflation uncertainty, real uncertainty, and the interest rate, the empirical model analog for the generalized Fisher equation (6) for stock market returns will be equations (7):[11]

$$E_t^{\ell}[R_s-\pi] = c_0 + c_1(R_{o,t}-E_t^{\ell}\pi) + c_2E_t^{\ell}\pi + c_3(v_{\varepsilon,t}\times 10^{-2}) + c_4(v_{\pi,t}\times 10^{-2}) \quad (7\text{-a})$$

$$E_t^{\ell}[R_s-\pi] = d_0 + d_1(R_{o,t}-E_t^{\ell}\pi) + d_2E_t^{\ell}\pi + d_3(v_{\varepsilon,t}\times 10^{-2}) + d_4\hat{\pi}^u_{t-1} + d_5\hat{\pi}^u_{t-2} \quad (7\text{-b})$$

where time subscripts denote the Livingston survey date; E^{ℓ} is the Livingston expectation operator; v_{ε} is the surrogate for σ_{ε}^2; v_{π} is the cross-sectional variance of the Livingston forecasted inflation rate; and lagged $\hat{\pi}^u$'s are the observed[12] Livingston unexpected inflation rates. v_{ε} and v_{π} are logarithm transforms in order to control for variable scale differences and possible heteroscadasticity.

INSERT TABLE I HERE

The statistical results for each of the two equations, (7-a) and (7-b), are shown in Table I.[13] First, our statistical results show that the effect of expected inflation on the real expected returns for common stocks becomes negative only when a measure for inflation uncertainty is introduced into the generalized Fisher equation. The systematically statisically significant positive coefficients for the real economic uncertainty and inflation uncertainty variables imply that expected real returns are adjusted for risk, as anticipated by our theoretical arguments.

Since the uncertainty variables in equations (7-a) are measured in logarithm (and scaled by multiplying with 10^{-2}), the regression coefficient estimates for the uncertainty variables in Table I suggest that a one

percent increase rate of the real uncertainty or inflation uncertainty variable is associated with more than a one percent increase in the real required return for common stocks. These results also indicate that the real required return for common stocks increases when inflation uncertainty increases, which could account for relatively depressed real stock prices during recent inflationary periods.[14] To the extent that the inflation level is interrelated with inflation uncertainty, our results may be in contrast with Geske and Roll's [1983] reverse causality hypothesis.[15] In particular, our findings suggest that one cannot rule out the existence of a causal relationship from inflation to stock returns.

Also, because of the possibility of intercorrelation between inflation and real uncertainty, the first principal component for these variables ($pc_{\varepsilon\pi}$) has been employed in equations (7-a) as a "composite general uncertainty" variable. As might be anticipated from the other findings, the coefficient of the composite uncertainty variable is positive and statistically significant, and does not affect the negative coefficient of the level of expected inflation variable (equations 7-a-9 and 7-a-10 in Table I).

Second, the negative relationship between the real required return for common stocks and the expected inflation rate, when controlling for inflation uncertainty, is consistent with the wealth effect hypothesis suggested by Mundell (see footnote 2). However, when the Fisher equation is misspecified by ignoring the interrelated effects of real and inflation uncertainty on the required return for common stocks, the coefficient estimates for the expected inflation variable will be

(spuriously) positive. Because the wealth effect hypothesis implies a stimulating effect of the level of expected inflation on real activity, the results may contrast with Fama's [1981] claim that real activity is negatively related to expected inflation.[16] In other words, the results, when controlling for real and inflation uncertainty, are consistent with the standard IS-LM analysis.[17]

Third, a necessary conditon for the Darby tax-effect to hold in our stock market model would be that the coefficients for expected inflation are statistically greater than zero. Therefore, the evidence in Table I, on balance, cannot be used to support the Darby hypothesis. Put differently, our empirical results in Table I suggest that the nominal expected stock returns (before personal taxes), after controlling for real and inflation uncertainty, respond less than point-for-point to changes in the rate of expected inflation.

Fourth, the overall fit of the regression equations in Table I improves dramatically when surrogates for inflation and real economic uncertainty are included as explanatory variables. The equations (7-a-1) and (7-a-2), regressing expected before tax real returns on expected inflation, explain less than twenty percent of the data variability. By including variables for inflation and real economic uncertainty, the overall fit increases significantly to the range of forty to fifty percent of the data variability. The improved overall fit coupled with the likely misspecification argument for equations (7-a-1) and (7-a-2) indicates that our findings are plausible.

Finally, our theoretical model treats, quite correctly, the ex ante real interest rate as a variable.[18] However, for our time period,

empirically suppressing the ex ante real interest rate variable (i.e., implicitly treating the ex ante real interest as a constant) does not affect our observed statistical interrelationships among expected real stock market returns, expected inflation and inflation uncertainty. That is, neither potentially negative relationships between the ex ante real interest rate and inflation nor changes in the real interest rate over time appear to affect our findings about the expected stock market return-expected inflation relationship.

III. CONCLUDING REMARKS

This note suggests that a clear distinction needs to be made between the level of inflation, the degree of inflation uncertainty and real economic uncertainty when examining the relationship between inflation and real economic variables such as real stock market returns. Our analysis shows that the misspecified relationship between expected stock returns and expected inflation, by ignoring the effect of inflation and real economic uncertainty on the required return, results in a spuriously positive relationship. The statistical results imply that an increase in expected inflation (controlling for inflation uncertainty) causes a decrease in the expected real rate of return for common stocks. These findings are consistent with the Mundell wealth-effect hypothesis, but do not provide empirical support for the Darby tax-effect hypothesis.

Our findings must be interpreted cautiously. As Levi and Makin [1978] observe, the Fisher equation should be viewed as a reduced-form equation, derived from a set of structural equations for a comprehensive macroeconomic model. Put somewhat differently, future empirical studies of the generalized Fisher equation might benefit from using explicitly a general equilibrium framework.

FOOTNOTES

[†]We are indebted to Irwin Friend, Stephen Turnovsky and two anonymous referees for their helpful comments. Of course, any remaining errors are our responsibilities. Research support from the Research Board at University of Illinois is gratefully acknowledged.

[1]The standard Fisher equation states that the nominal rate of return on an asset can be decomposed into the real rate of return lenders (investors) expect plus an adjustment for the rate of expected inflation over the asset's term to maturity.

[2]The wealth effect hypothesis states that an increase in expected inflation causes portfolio substitutions from money to financial assets such as common stock. Therefore, an increase in expected inflation causes a decrease (increase) in the expected return (current price) of common stocks, which stimulates economic activity. See, also, Tobin [1965].

[3]Because nominal income is taxed, investors are concerned about the expected net real rate of return after taxes. The importance of the distinction between expected real rates of interest before taxes and after taxes was emphasized by Darby [1975] and Feldstein [1976]. The Fisher equation can be modified to adjust for income tax "leakages"; see equation (5).

[4]See, for example, Friend and Blume [1975].

[5]This finding has been documented by many studies since the mid-1970's. See, for example, Fama [1981] and the references therein.

[6]Historically, high levels of inflation tend to be associated with high inflation uncertainty (both in the U.S. and other countries). See Okun [1971] and Logue and Willet [1976], among others.

[7]Let $Y = \phi_1 X_1 + \phi_2 X_2$ (true model) and $Y = \gamma_1 X_1$ (misspecified model) where Y, X_1, and X_2, respectively, denote the nominal expected return on common stocks, the expected inflation rate, and the measure of inflation uncertainty. Then, the true OLS estimate of $\hat{\phi}_1$ will be:

$$\hat{\phi}_1 = \frac{\gamma_1 - \frac{\sigma_{12}}{\sigma_{11}} \frac{\sigma_{2y}}{\sigma_{22}}}{1 - \rho_{12}^2}$$

From the Livingston data, σ_{12}/σ_{11} is between 2 and 4; σ_{2y}/σ_{22} is about 1; and ρ_{12} is between 0.5 and 0.8. Then, $\frac{\sigma_{12}}{\sigma_{11}} \frac{\sigma_{2y}}{\sigma_{22}} > \rho_{12}^2$. Given that the estimates for $\hat{\gamma}_1$ are in the range of 1.5 to 2.5 (see Gultekin's [1983] Table II, p. 668), the misspecified model yields $\hat{\gamma}_1 > \hat{\phi}_1$; that is, the misspecified model overestimates the effect of expected inflation on expected stock returns.

[8]The procedures for computing forecasted rates are described in Carlson [1977] and Gultekin [1983].

[9]See Cukierman and Wachtel's [1979] formal proof and Bomberger and Frazer's [1981] empirical evidence for using the Livingston cross-sectional variance as a proxy for uncertainty.

[10]The nature of uncertainty associated with high inflation could emanate from unpredictable relative price changes, i.e., a less efficient price system (see Vining and Elwertowski [1976]). Fischer [1981] shows that the variance of relative price changes tends to increase (decrease) when unexpected inflation (deflation) occurs. Considering this asymmetry, one should distinguish between "inflation" uncertainty and "deflation" uncertainty. Hence, the absolute values of forecast errors are likely to be an inappropriate proxy for "inflation" uncertainty.

Our study also shows that there is an internal consistency between the Livingston cross-sectional variance of inflation forecasts and the Livingston unexpected inflation rates: the correlation coefficients of $v_{\pi,t}$ with $\hat{\pi}_t^u$, $\hat{\pi}_{t-1}^u$ and $\hat{\pi}_{t-2}^u$ are, respectively, 0.717, 0.723 and 0.663 for the post-1960 period.

[11]If we assume the ex ante real interest rate (after tax) is constant (i.e., empirically suppress $R_o - E[\pi]$ in equations 7), the coefficient of expected inflation in equations (7) is $\delta_s - 1$. If the ex ante real interest rate is represented by $R_o - E[\pi]$, the coefficient of expected inflation in equation (7) becomes $\delta_s - \delta_o$; where δ_o measures the Darby tax-effect in the bond market (viz. $R_o = E[r_o]/(1-\tau) + \delta_o E[\pi]$). Earlier studies show that the magnitude of δ_o is at most unity, and if the real interest rate is proxied by $R_o - E[\pi]$, then, the coefficient for expected inflation in equations (7) will be $\delta_s - \delta_o > \delta_s - 1$.

[12]Let the subscript t-1, for example, represent the December 1980 survey. $\hat{\pi}_t^u$ is defined as the unexpected inflation rate from the beginning of January 1981 to the end of June 1981 (i.e., the forecast error of the inflation predicition of the December 1980 survey). Note that this forecast error was not observed when the June 1981 survey (represented by the subscript t) was conducted in early June or late May of that year. As a proxy for inflation uncertainty, only realized forecast errors are present in the regression equation (7-b).

[13]Since there is compelling evidence for a structural break in the Livingston data around 1960 (see Brown and Maital [1981], among others), the results for equations (7) are examined separately for two periods: (i) June 1960 to June 1980; and (ii) June 1955 to June 1980. There is no qualitative difference in the results for these two periods; and, thus, the results for the post-1955 period are not reported to save space.

[14]See, also, Malkiel [1979], Friend [1982], and Dokko and Edelstein [1985].

[15]Geske and Roll [1983] hypothesize that the changes in the real required return for common stocks are inconsequential in explaining the observed negative relationships between inflation and stock returns (p. 9); and suggest that a decrease in stock prices, in an efficient stock market, signals an increase in the government's monetized debt and its consequence, inflation; that is, a reverse causality from stock returns to inflation.

[16]Fama [1981] asserts that real economic activity is negatively related to inflation. Therefore, according to Fama, given that stock returns are determined principally by expectations about real activity, the observed negative relationship between expected inflation and subsequently realized stock returns is spurious, and is the result of a real income proxy effect of inflation.

[17]Earlier studies recognized the adverse effect of inflation <u>uncertainty</u>, not the inflation <u>level</u> per se, on macroeconomic activity (e.g., Lucas [1973]). One needs to distinguish clearly between the effect of the inflation level and the effect of inflation uncertainty on real activity. Friedman [1977], in his Nobel Laureate Lecture, argues that increased inflation uncertainty reduces the growth rate of real output because it becomes harder to extract the signal about relative prices from absolute prices (i.e., the price system becomes less efficient). Mullineaux [1980] provides empirical support for Friedman's argument.

[18]See Mishikin [1981] and Startz [1981], among others.

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Table I

REGRESSION RESULTS FOR EQUATIONS 7
JUNE 1960 THROUGH JUNE 1980

Equation 7-a: $E_t^{\ell}[R_s-\pi] = c_0 + c_1(R_{o,t}-E_t^{\ell}\pi) + c_2E_t^{\ell}\pi + \left\{\begin{array}{l} c_3(v_{\varepsilon,t}\times10^{-2}) + c_4(v_{\pi,t}\times10^{-2}) \\ c_5(pc_{\varepsilon\pi,t}\times10^{-2}) \end{array}\right.$

Eq. No.	c_1	c_2	c_3	c_4	c_5	Adj. R^2	F	DW
7-a-1*	--	0.676 (0.357)†	--	--	--	0.198	3.57	1.90
7-a-2*	0.157 (0.732)	0.723 (0.423)†	--	--	--	0.178	1.77	1.90
7-a-3*	--	0.377 (0.284)	2.046 (0.509)†††	--	--	0.416	11.08	1.95
7-a-4*	0.624 (0.614)	0.538 (0.322)	2.151 (0.517)†††	--	--	0.416	7.88	1.92
7-a-5	--	-1.424 (0.585)†††	--	3.066 (0.784)†††	--	0.348	11.66	1.56
7-a-6	-0.451 (0.622)	-1.643 (0.661)†††	--	3.210 (0.814)†††	--	0.339	7.85	1.61
7-a-7	--	-1.290 (0.506)†††	1.731 (0.454)†††	2.366 (0.698)†††	--	0.519	15.37	1.79
7-a-8	0.138 (0.561)	-1.138 (0.588)††	1.764 (0.480)†††	2.308 (0.745)†††	--	0.506	11.25	1.79
7-a-9	--	-1.571 (0.445)†††	--	--	3.235 (0.569)†††	0.505	21.42	1.76
7-a-10	-0.146 (0.531)	-1.621 (0.486)†††	--	--	3.251 (0.579)†††	0.493	13.96	1.78

Table I (continued)

Equation 7-b: $E_t^{\ell}[R_s-\pi] = d_0 + d_1(R_{o,t}-E_t^{\ell}\pi) + d_2E_t^{\ell}\pi + d_3(v_{\varepsilon,t}x10^{-2}) + d_4\hat{\pi}^u_{t-1} + d_5\hat{\pi}^u_{t-2}$

Eq. No.	d_1	d_2	d_3	d_4	d_5	Adj. R^2	F	DW
7-b-5	--	-0.358 (0.302)	--	1.477 (0.364)†††	0.970 (0.352)†††	0.437	11.34	1.90
7-b-6	-0.548 (0.634)	-0.538 (0.367)	--	1.623 (0.403)†††	0.887 (0.367)††	0.433	8.64	1.95
7-b-7	--	-0.379 (0.259)	1.630 (0.435)†††	1.303 (0.316)†††	0.584 (0.320)††	0.583	15.00	1.90
7-b-8	-0.091 (0.565)	-0.409 (0.321)	1.613 (0.453)†††	1.329 (0.360)†††	0.574 (0.330)†	0.572	11.68	1.90

Footnotes:

* indicates that the corresponding regression has been adjusted for the first-order autocorrelation using the Cochrane-Orcutt adjustment.

Standard errors are in parentheses below the coefficient estimates: † denotes significance at the 10% statistical level, †† denotes significance at the 5% statistical level, and ††† denotes significance at the 1% statistical level.